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Employment in Renewable Energy Activities, Australia methodology

Reference period 2017-18 financial year

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Explanatory notes

Renewable energy employment

Definition and scope

1 In this publication renewable energy employment is defined as employment in activities principally motivated by the production of renewable energy, and/or by the design, construction and/or operation and maintenance of renewable energy infrastructure. These renewable energy activities are carried out within institutional units and for some of these units, renewable energy activities are its predominant activity. In other cases, the renewable energy activity occurs as a secondary activity of the institutional unit. Nevertheless, employment related to all such renewable energy activities is in scope of this publication.

Categories of renewable energy

2 Renewable energy may be generated from a number of sources. Within Australia the

Renewable Energy (Electricity) Act 2000 describes the range of renewable energy sources eligible under this act and these form the basis of renewable energy types contained in this publication. The broad categories of renewable energy types are:

- Solar - Roof-top photovoltaic (PV)
- Solar - Hot Water System
- Solar - Large scale
- Wind
- Hydro
- Biomass
- Geothermal
- Wave.

3 In addition, a significant number of employees of government bodies and non-profit institutions (NPIs) are engaged in activities directly and predominantly motivated by the promotion, administration and production of renewable energy and of renewable energy infrastructure. Within this publication the following additional category of renewable energy activity is included:

- Government and non-profit institutions (NPIs).

4 Government and NPI employees are recorded separately from the other categories of renewable energy, since these employees are typically engaged in activities that cut across various types of renewable energy. For example, an employee of the Clean Energy Regulator who carries out tasks related to the administration of Australia's renewable energy target is principally motivated by the delivery of a market infrastructure to promote all types of renewable energy. Since Australia's renewable energy target promotes a range of renewable energy types, it is not appropriate to assign employees of an entity such as the Clean Energy Regulator to a specific type of renewable energy. Instead, they are assigned to a separate category 'Government and NPIs'.

Scope of renewable energy activities

5 This section briefly describes the scope of activities included under each category of renewable energy and for government and NPIs. Direct full time equivalent (FTE) employment in renewable activities relates specifically to the following activities.

Solar - roof-top photovoltaic

6 Employment in solar roof-top photovoltaic (PV) activities extends to all activities required

to install small scale solar power infrastructure. This includes such activities as site preparation; roof modifications; electrical preparations (e.g. powerboard upgrade and/or meter replacement); installation of racking for solar panels, solar panels and inverter; and testing and certification of installed systems. It also includes related retail activities and project management. Employment in operation and maintenance of roof-top solar PV is in scope, however no estimates have been made of employment in these activities because it is assumed to be insignificant due to the low maintenance generally required for this infrastructure and the low average age of solar panels currently installed in Australia.

7 Note that while these activities are described as relating to 'roof top PV' solar, in fact they include employment activities related to all solar PV systems with the exception of those related to the category of Solar - large scale.

Solar - hot water system

8 Employment in solar hot water system activities includes installation of solar hot water systems (HWS) and heat pump hot water systems, either into new dwellings; or into existing dwellings as a replacement for existing solar or heat pump HWS or as retrofitted conversion to solar or heat pump HWS. Direct employment in renewable energy activities relates to those employment activities needed to carry out the installation of the solar or heat pump HWS, for example, site preparation, system design, system installation, project management and administration. It also includes manufacturing of solar HWS in Australia (though not heat pump HWS), as well as repair and maintenance activity carried out on installed solar or heat pump HWS.

Solar - large scale

9 Employment in large scale solar activities includes employment activities related to all solar power systems with an installed capacity of 100kW or greater. The estimation methodology used in this publication for employment in large scale solar activities requires the creation of a listing of all large scale solar operations in Australia. The data source used to create this listing applies a cut-off point of 100kW and the estimates contained in this publication observe the same cut-off. In practice, large scale solar includes two broad types of solar power infrastructure. The first is a larger version of household roof-top solar PV installations, typically sited on the roof of commercial operations such as shopping centres, hospitality clubs or factories. The owner of this type of infrastructure is usually seeking to defray a significant electricity expense. The second, and far more significant, type of large scale solar infrastructure is a dedicated solar farm allowing the electricity producer to supply electricity to the grid for sale to third-party customers. This type of infrastructure will allow its owner to gain accreditation under the Large-scale Renewable Energy Target (LRET). In both cases, employment in renewable energy activities relates to those direct

employment activities needed to carry out the installation of large scale solar, such as site preparation, system design, system installation, project management and administration. Also included is associated enabling technology such as big batteries used to address the inherent intermittency of solar power, in addition to providing grid stability. In principle, it also includes employment related to the ongoing operation and maintenance of large scale solar power infrastructure and estimates for such activity will be included in the next edition of this publication.

Wind

10 Employment estimates for wind power encompass two broad areas of activity: installing wind power infrastructure such as concrete slabs, towers, turbines, grid connection and access roads; and the ongoing technical operation and maintenance of wind power infrastructure. The former is primarily undertaken by employees of engineering and construction, transport and similar businesses. The latter is typically carried out by employees of the wind power infrastructure operator. Small scale roof-top wind turbines are also a form of wind power generation. However, employment in small scale wind has not been included in this publication as only a very small number have been installed over the reporting period and it is currently not a widely utilised technology. Employment in wind power also includes associated enabling technology such as big batteries used to address the inherent intermittency of wind power, in addition to providing grid stability.

Hydro

11 Employment in hydropower activities includes all activities required to carry out hydropower operations, including those related to operating and managing hydropower assets to generate hydroelectricity. In addition to the range of technical activities needed to carry out these operations, hydropower activities include such things as related retail activity; engagement with local and national electricity markets; management of environmental assets and engagement with various hydropower stakeholders. Planning and construction of hydropower capital works are also in scope, and these activities include the construction and/or upgrade of dams for hydropower (including pumped storage hydro-electricity); upgrade and/or replacement of key technical components such as turbines and transformers; and capital works related to distribution assets such as grid connections, poles, wires and other distribution structures.

12 This category also includes employees involved in designing, developing and installing micro hydro power infrastructure.

Biomass

13 Energy from biomass includes bagasse (fibrous sugar cane waste); bio ethanol; bio diesel;

gas from landfill; sewage gas; and crop and livestock waste. Direct employment in biomass energy activities includes the design, construction and maintenance of infrastructure used to create energy from biomass. It also includes employees who operate this infrastructure when its primary purpose is to generate renewable energy.

14 Direct employee numbers for biomass do not include those engaged in cultivating biomass feedstock, such as red sorghum or sugar cane, for use in generating bio-energy. It also does not include employees engaged in pulp and paper manufacturing - a process from which black liquor may be created as a renewable energy by-product. The primary reason for pulping wood chips under a kraft milling process is to support the production of paper products; the creation of black liquor is a secondary (though valuable) outcome. This is also the case for red sorghum and sugar cane as they are primarily grown for other purposes and renewable energy is created as a secondary product.

15 However, the use of bagasse (fibrous sugar cane waste) to generate electricity can and does give rise to direct employment in biomass energy activities. A number of sugar mills in Australia continue to operate beyond the conclusion of the sugar cane crushing season, at which point their output is made up exclusively of electricity sold to the grid. At this point in time, the employees in these mills are engaged in activities principally motivated by the production of a renewable energy product. Employment in these mills, in the period outside the sugar cane crushing season, is thus treated in this publication as employment in renewable energy activities.

Geothermal

16 At present, Australia's geothermal energy operations remain essentially exploratory exercises with only a small amount of operational capacity developed to date. Employment in geothermal power activities therefore mostly relates to the development of geothermal energy infrastructure i.e. site preparation, system design, drilling, system installation, related transport activity, project management and administration. Activities related to the decommissioning and restoration of non-viable sites are not in scope of this publication.

17 Academic research into geothermal energy is concentrated into dedicated centres located within Australian universities. Employees engaged in these activities have been assigned to the category 'government and NPIs'.

Wave

18 The use of ocean waves, tides or current to generate energy is currently at early production stages within Australia. Renewable energy activities relevant to estimates of direct employment in wave energy include the design, construction and operation and maintenance of wave energy infrastructure.

19 Employment in this area is small and there is very little publicly available data on employment in wave energy activity in Australia. As a result it was decided to omit estimates of annual direct FTE employment in wave energy activities.

Government and non-profit institutions

20 The scope of this publication includes activities undertaken by employees of government agencies and non-profit institutions (NPIs) to support the operation of renewable energy systems, for example, administration, legal, policy or advocacy roles. Thus, employment in regulatory bodies such as the Clean Energy Regulator is in scope. Some government agencies and NPIs provide support that is critical to the go-ahead of many renewable energy projects and the employees of these units are also considered to be renewable energy employees. Examples of the latter include the Clean Energy Finance Corporation (CEFC) and Australian Renewable Energy Agency (ARENA). Employees engaged in renewable energy advocacy are also included, for example, employees of peak bodies representing various renewable energy technologies.

Direct / indirect employment in renewable energy activities

21 International statistical standards do not define direct and indirect employment; however, the concepts are straightforward for standard industries. For example, direct employment in the mining industry refers to jobs created by the actions of units predominantly engaged in mining activity.

22 The concept becomes less straightforward in the context of non-standard industries, or for specific projects. For example, no 'Tourism' industry exists within standard industry statistics produced by official statisticians. Tourism is defined in terms of the consumer of the product such that, for example, some consumers of accommodation services are engaged in tourism activity and some are not. Thus, it is difficult to determine where 'tourism' employment starts and finishes. In the case of tourism, the direct effect relates solely to the immediate effect of expenditure made by visitors. For example, when a tourist uses a taxi service, the direct employment effect includes the proportion of the driver's employment that is spent driving tourists. The indirect effects on employment would include employees hired by the petrol stations, garages and food outlets needed to provide the taxi driver with petrol, motor servicing and meals while on duty. Renewable energy activity, like tourism, does not constitute a standard industry within industrial classifications.

23 Direct employment in renewable energy activities is employment directly related to the production of renewable energy, and/or by the design, construction and/or maintenance of renewable energy infrastructure. The section above 'Scope of renewable energy activities' describes the specific activity inclusions for each type of renewable energy. For example, an

installer of roof-top solar PV will undertake a range of activities to design and install this infrastructure. That is, direct employment relates to such activities as site preparation; roof modifications; electrical preparations (e.g. powerboard upgrade and/or meter replacement); installation of racking, solar panels and inverter; and testing and certification. It includes any subsequent call-out for repairs and maintenance, and also retail activities and project management. Indirect employment comprises all people who work in the production of intermediate inputs related to installing, operating and maintaining renewable energy infrastructure. It arises from such things as general supplies used in the installation process (e.g. wiring, conduit, replacement roof tiles), servicing of transport equipment, meals consumed on the job and so on. If the installer of roof-top solar PV does general electrical work such as replacing powerpoints or light fittings, this is not employment in renewable energy activities (of either a direct or indirect kind).

Estimation methodology

24 Renewable energy is not readily discernible from the standard product and industry classifications used within official statistical series. For example, within the 2006 edition of the [Australian and New Zealand Standard Industrial Classification \(ANZSIC\), 2006 \(https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1292.0Main+Features12006%20\(Revision%202.0\)\)](https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1292.0Main+Features12006%20(Revision%202.0))) (cat. no. 1292.0), renewable energy is separately identified within Class 2612 Hydro-Electricity Generation, but no other renewable energy activity is separately identified in this way. Units whose predominant activity is to generate electricity from wind, solar, biomass, geothermal or wave energy are not separately identified but are recorded together within ANZSIC Class 2619 Other Electricity Generation. In cases where renewable energy is not the predominant activity of the producing unit, for example, the use of black liquor by some paper manufacturers, standard industry statistics will instead record economic activity against the predominant activity of the unit. The installation of renewable energy infrastructure is an important example of ANZSIC treating activity not as part of a renewable energy industry but instead as construction activity or as professional, scientific and technical services. The cross-cutting nature of renewable energy means that, while renewable energy activity is in scope of the national accounting framework, it is captured in a way that does not support its full and separate identification.

25 National statistical agencies do not typically conduct surveys on renewable energy activities. In producing the experimental estimates contained in this publication the ABS has used three broad approaches. These approaches are as follows:

- Accessing publicly available information such as company annual reports, media reports, information provided on company websites, industry association reports and data drawn from the Renewable Energy Certificate (REC) Registry maintained by the Clean Energy

Regulator.

- Making use of the employment factor approach (discussed below).
- Using employment numbers provided directly by the institutional unit.

Employment factor approach

26 The employment factor approach has been used to estimate employment in renewable energy activities by type of renewable energy. It utilises information on installed capacities of renewable energy infrastructure (i.e. how much renewable energy is potentially produced by renewable energy infrastructure), numbers of installations and employment factors. Employment factors indicate the number of annual direct full time jobs created per physical unit of choice, for example, numbers of annual FTE employees created per megawatt (MW) of installed capacity of wind power. It is an estimation technique that has been used internationally to generate employment numbers associated with renewable energy activities.

27 The critical element of this methodology is the employment factor itself and this has been estimated on the basis of publicly available information linking generation capacities and employment for specific projects, case studies, industry surveys, feasibility studies and technical literature specifications related to renewable energy operations.

28 Employment factors used within this publication are described in the section immediately below, against the relevant categories of renewable energy.

29 An international summary of employment factors is published by the International Renewable Energy Agency (IRENA) in [Renewable Energy and Jobs \(2018\)](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/May/IRENA_RE_Jobs_Annual_Review_2018.pdf) (https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/May/IRENA_RE_Jobs_Annual_Review_2018.pdf). While the ABS has made some use of this summary, employment factors vary significantly over time and from country to country and must be interpreted and used with caution. They reflect different employment functions inherent within different countries, leading to significant variation in employment numbers per unit of installed capacity of renewable energy. For example, the lower price of labour in developing countries often results in significantly more FTE employment per MW of installed capacity than is the case for high labour cost developed countries. Employment functions are observed to change over time, sometimes quite rapidly, as technological improvements are achieved in renewable energy equipment and as the technical expertise of designers, managers and installers grows.

Estimation methodology, by type of renewable energy

Solar - roof-top PV

30 The employment factor approach was used to estimate annual direct FTE employment associated with roof-top solar PV power.

31 The Clean Energy Regulator reports information on installed capacity of roof-top solar PV infrastructure in Australia. The number of installations is used to calculate employment using the employment factor approach.

32 A number of countries have developed estimates of employment related to the installation of roof-top solar PV by using employment factors expressed per MW of installed capacity of solar PV (IRENA, 2013). These data were compared to data yielded by recent Australian case studies which show significantly lower levels of employment per MW of installed capacity than typically reported overseas. There are a number of reasons for these differences. In the first instance, the Australian figures assume that no domestic employment arises from the manufacturing of solar components (panels, inverters, racking etc.) and this assumption does not hold true for some other countries. A second more critical factor is the age of many of the international estimates. Given the dramatic recent decline in the price of roof-top solar PV components, it has become more affordable to install larger systems. With the recent growth in the average size of roof top solar PV systems installed, annual employment per MW of installed capacity has also fallen greatly.

33 On the basis of case study investigations the ABS has determined that in using the employment factor approach, the more meaningful physical variable is employment per roof-top solar PV system installed, rather than per MW of installed capacity of roof-top solar PV. Larger roof-top solar PV systems have more solar panels and more racking and their installation therefore requires somewhat more labour. However, the majority of tasks making up a roof-top solar PV system installation take equally long to complete for a small system as for a large one. For example, time spent on sales activity; project management; processing of renewable energy certificates (RECs); transport to and from the work site; roof preparation; installation of inverter; upgrade of powerboard; replacement of electricity meter and regulatory checks; are either completely or largely independent of the size of the roof-top solar PV system installed.

34 The average size of a roof-top solar PV system installed in Australia increased substantially between 2009-10 and 2017-18. The estimation methodology used by the ABS recognises that roof-top solar PV systems are now larger and therefore take longer to install. Equally, it is recognised that over this brief time series efficiency gains have been made in the installation of roof-top solar PV systems.

35 The ABS case study findings focussed specifically on the labour required at the work site to install roof-top solar PV infrastructure. To this is added employment associated with various 'business process costs' (e.g. sales, planning and administration costs) needed for

the installation of roof-top solar PV. The scaling up of employment factors to include these 'business processes' has been carried out using figures sourced from the International Renewable Energy Agency (IRENA 2012, p20) and from discussions with experts on the operation of the Australian solar power industry.

Solar - hot water system

36 The employment factor approach was used to estimate annual FTE employment associated with the installation and servicing of solar hot water systems and heat pump hot water systems.

37 Estimates of the number of solar hot water systems and heat pump hot water systems installed, both cumulatively and for individual years, is sourced from the Clean Energy Regulator. The employment factor is based on case study information and on publicly available information and is expressed as hours worked per installation of each solar hot water system or heat pump hot water system. The factors used consider employment activities related to the installation of solar hot water systems and heat pump hot water systems and to the manufacture of solar hot water systems within Australia. Note that installations made to an existing home will take longer than an installation to a new dwelling and that the employment factor also considers ongoing servicing of both solar hot water and heat pump hot water systems.

Solar - large scale

38 The employment factor approach was used to estimate annual FTE employment associated with large scale solar power.

39 Limited information is available internationally on employment factors per MW of installed capacity of large scale solar power. This may be explained by the fact that, until recently, large scale solar struggled to compete on cost grounds with other forms of renewable energy, particularly wind. Instead, international data on employment per MW of installed capacity was more likely to pertain to the installation of roof top solar PV and other applications of solar power. As is the case for wind power, most of the data available internationally on employment per MW of installed capacity of solar power appear considerably higher than could be justified for the Australian context.

40 Many large scale solar power operations have recently been either proposed or completed in Australia. Typically the owners have established public websites providing extensive information on the scale and nature of these operations, including details on employment. By using a combination of this publicly available information, assumptions about the relationship between jobs and annual FTE employment, and by incorporating an element of employment related to the planning and development of the solar farm, it has

been possible to derive an employment factor expressed as annual FTE employment per MW of installed capacity of large scale solar power.

41 Within the current release, the employment factor used by the ABS for large scale solar power has been revised downwards considerably for reference year 2015-16 and onwards. The Clean Energy Council maintains a [tracker of large scale renewables projects \(https://www.cleanenergycouncil.org.au/resources/project-tracker\)](https://www.cleanenergycouncil.org.au/resources/project-tracker) taking place across Australia. It reports various details for each of these projects, including proposed installed capacity and expected employment. This source formed the starting point for ABS revisions to its employment factor for large scale solar power. This factor remains at the lower end of the spectrum of international observations.

Wind

42 The employment factor approach has been used to estimate annual direct FTE employment for wind power.

43 A list of relevant businesses engaged in wind power operations was compiled using publicly available information. This list contains data on each wind farm in Australia, including: state/territory; start/finish date of construction activity; and installed capacity of the wind farm. Employment factors were generated for: direct FTE annual employment related to construction activity; and direct FTE annual employment related to ongoing operation and maintenance of the wind farm. The employment factors were determined based on various Australian studies, taking into account information publicly released by a number of companies installing wind power in Australia, and after consideration of published results from around the world.

44 The employment factors used in this publication were selected after confrontation with other available data, in particular, after comparison with information publicly released by a number of Australian companies delivering and operating renewable energy projects. Official company reports and website information on renewable energy projects frequently set out expected and actual employment levels related to these projects, as well as project start and finish dates and installed capacity in MW. These figures were used to derive observed estimates of employment factors for specific projects and to help determine which employment factors were the most appropriate to Australian operations for the period in question. The employment factors used for wind power in this publication are at the lower end of the range of factors published internationally.

45 A high priority is placed on obtaining recent observations because the recent rapid increase in size of wind turbines and blades impacts directly on per-MW employment factors. In addition, Australia's status as a high wage cost country necessarily restricts useful

comparisons to employment factors from similarly high wage cost countries i.e. where greater pressure exists to maintain the minimum workforce necessary to complete the task. Employment factors used in many overseas studies include a large manufacturing component but for Australia the amount of employment related to manufacturing of renewable energy equipment is much less. This is further justification for use of employment factors that are at the lower end of the spectrum of international data. Finally, employment factors used for wind power in this publication do not consider employment related to decommissioning or refurbishment of renewable energy infrastructure, primarily because most of Australia's renewable energy infrastructure is relatively young and very few wind power operations have ended their productive life.

46 Within the current release, the employment factor used by the ABS for construction of wind power infrastructure has been revised downwards for reference year 2016-17 and onwards. The Clean Energy Council maintains a [tracker of large scale renewables projects](https://www.cleanenergycouncil.org.au/resources/project-tracker) (<https://www.cleanenergycouncil.org.au/resources/project-tracker>) taking place across Australia that reports various details for each of these projects, including proposed installed capacity and expected employment. This source formed the starting point for ABS revisions to its employment factor for wind power.

Hydro

47 The estimation process used a list of Australia's active hydropower sites compiled from a range of publicly available sources.

48 In Australia, the majority of hydropower operations are carried out by large enterprises predominantly engaged in the provision of hydropower. For these enterprises, employment data were taken from publicly available annual reports and from other information publicly available on related websites. However, there are also enterprises that predominantly rely on power from a range of sources that include hydropower operations as part of their energy mix. For these enterprises, employment data were mainly obtained from information publicly available from their websites. In some cases, however, employment numbers could not be retrieved from websites and were instead supplied directly from the enterprise, or estimated based on the installed hydropower capacity of the operations.

49 For two hydropower operators the ABS has adjusted information taken from publicly available sources. These adjustments are explained below.

50 Snowy Hydro Limited reported employment data in respect of 2012-13 on its company website. In order to extrapolate beyond 2012-13 to 2017-18, an indicator was built to approximate movements in FTE employees of Snowy Hydro. The indicator is 'Employee Benefits Expense' taken from annual reports of Snowy Hydro, divided by average hourly

cash earnings of full-time non-managerial adult employees of the electricity supply industry, sourced from the ABS publication [Average Weekly Earnings, Australia \(https://www.abs.gov.au/ausstats/abs@.nsf/mf/6302.0\)](https://www.abs.gov.au/ausstats/abs@.nsf/mf/6302.0) (cat. no. 6302.0)

51 The Hydro Tasmania 2016 Annual Report presents employee numbers by calendar year up to reference year 2016. The ABS deducted an estimate of Hydro Tasmania employees engaged in wind power activities from this total. This adjusted calendar year series has been converted to a financial year basis using the average of adjoining calendar year estimates. In its 2017 and subsequent annual reports, Hydro Tasmania has presented employment numbers as at 30 June and no balance date adjustment has been applied by the ABS for estimates related to 2016-17 and 2017-18.

Biomass

52 Estimates of annual FTE employment in energy from biomass are derived in three ways: by using publicly available employment estimates, by using the employment factor approach and by sourcing FTE estimates directly from biomass producers.

53 Four distinct sets of estimates make up employment in energy derived from biomass: bagasse, bio ethanol, bio diesel and landfill gas. Employment related to the use of bagasse is estimated using publicly available information on the export of electricity to the grid by sugar mills and on the numbers of employees of such mills. For bio ethanol and bio diesel production, employment data are obtained substantially from publicly available information. In some cases, employment has been estimated based on the installed capacity of the plant, given knowledge of employment numbers for similar sized operations.

54 Employment in landfill gas includes both design/installation of landfill gas infrastructure and ongoing operation and maintenance of this infrastructure. Publicly available information provided estimates of employment in the design and installation of landfill gas infrastructure. A number of landfill gas operators have placed information on public websites relating to employment numbers and installed energy capacity. From these observations, an employment factor was derived and used for other landfill energy operations in Australia.

Geothermal

55 Estimates of annual FTE employment in geothermal operations are derived using a list of Australia's active geothermal sites. Publicly available information provided estimates of employment primarily in the construction and operation of related infrastructure.

Government and non-profit Institutions

56 Government agencies and non-profit Institutions (NPIs) generally provide good web-

based information on their operations, including employee numbers. This was the principal source used for estimation of annual direct FTE employment in renewable energy activities within government and NPI units. Where information could not be sourced from publically available sources, employment numbers were supplied by the agency or NPI.

57 The estimates published here are likely to understate the true levels of renewable energy employment within government and NPIs. It is likely that a significant number of these entities employ numbers of people engaged in work directly related to renewable energy, for example, local council employees that develop and administer guidelines related to roof top solar systems, or employees of state government agencies that manage environmental aspects of wind farm proposals. This publication includes employment data where publicly available government information identifies an entire agency or an entire program engaged in renewable energy activities.

58 A number of universities, often in partnership with outside entities, undertake research and development related to renewable energy. Employment in these types of activities is included in this publication, for example, employment in developing understanding and design of geothermal operations. However, care has been taken to exclude employees engaged in energy efficiency developments, or in research related to institutional and/or economic aspects of renewable energy. Persons engaged in renewable energy activities under Doctoral or Visiting arrangements are also excluded from these estimates of FTE employment. Care has been taken not to double-count employees where university departments are working in partnership with industry.

59 A number of government and NPI employees are engaged in climate change related work, for example, climate change policy development, advice, training and inter-disciplinary collaboration. Although renewable energy is a central consideration of climate change policy, these employees are not specifically engaged in renewable energy activities and are excluded from the estimates contained in this publication.

Appendix

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International statistical standards and the concept of employment in renewable energy activities

The development of experimental statistics, such as the estimates of employment in renewable energy activities contained in this publication, relies heavily on what can be sourced from within the data environment presently available. Nevertheless, it is critically important to have a clear concept of what is to be measured. This section describes the

notion and scope of estimates of employment in renewable energy activities used in this publication.

International standards and guidelines exist to guide our understanding and definition of various aspects of the economy including production, consumption and employment. However, there is little in the way of international guidance on what precisely is meant by employment in renewable energy activities.

The 2008 edition of the System of National Accounts (SNA) defines employees as "persons who, by agreement, work for a resident institutional unit and receive remuneration for their labour." (SNA, paragraph 19.20.)

SNA (paragraph 19.19) defines employment as "all persons, both employees and self-employed persons, engaged in some productive activity that falls within the production boundary of the SNA and that is undertaken by a resident institutional unit."

SNA (paragraph 1.7) describes the range of economic activities that institutional units may engage in, namely, production, consumption and the accumulation of assets.

Employment in renewable energy activities thus relates to both employees and self-employed persons engaged in productive activities falling within the production boundary of the SNA. (From this position, the definition of 'renewable energy activities' becomes crucial and this is described in detail within the Explanatory Notes of this publication.)

The guiding principle of industry classification is the grouping together of all establishments engaged in the same or similar, kinds of activity (SNA 2008, paragraph 5.2). Productive activities are carried out by institutional units and each institutional unit is allocated to an industry on the basis of its predominant activity. All employees of this institutional unit are in consequence allocated to this same industry. Thus, in official ABS Labour Market statistics, industry estimates of employment involve assigning employees to the industry of their employer. The 2006 edition of the [Australian and New Zealand Standard Industrial Classification \(ANZSIC\), 2006](https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1292.0Main+Features12006%20(R revision%202.0)) ([https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1292.0Main+Features12006%20\(R revision%202.0\)](https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1292.0Main+Features12006%20(R revision%202.0))) (cat. no. 1292.0) provides the basis for these industry estimates.

Standard industry classifications are designed to capture and separately identify a wide range of types of economic activity. For example, units predominantly engaged in aluminium smelting typically do not undertake significant secondary activity. Nor is aluminium smelting typically carried out by other industries as a secondary activity. Thus, in practice, employment assigned to the industry 'ANZSIC Class 2132 Aluminium Smelting' should equate closely to numbers of employees who undertake the activity of aluminium

smelting. The same is not generally true of renewable energy activities. Some employment in renewable energy activities relates to the secondary activity of an employer whose predominant activity is not a renewable energy activity. In particular, much of this employment relates to the installation of renewable energy infrastructure by units that are predominantly engaged in construction or other activities.

To a limited degree ANZSIC 2006 supports the direct capture of employment in renewable energy activities. Hydropower is classified in ANZSIC as "2612 Hydro-Electricity Generation" and ANZSIC "2619 Other Electricity Generation" will also capture, in total, much of the remaining activity related to electricity produced from renewable sources.

Glossary

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Accredited solar PV installer

The Clean Energy Council holds the authority to grant accreditation to installers of solar photovoltaic (PV) systems. A solar PV system installed by an accredited installer becomes eligible for feed in tariff and Small-scale Technology Certificates.

Air sourced heat pump

Air sourced heat pumps are hot water systems that use a refrigeration cycle to extract heat from the air to heat water. Small scale technology certificates are applicable to air sourced heat pumps.

ANZSIC

The Australian and New Zealand Standard Industrial Classification (ANZSIC) is the standard classification used in Australia and New Zealand for the collection, compilation, and publication of industry statistics.

ASGS

The Australian Statistical Geography Standard (ASGS) brings together in one framework all of the regions which the Australian Bureau of Statistics (ABS) and many other organisations use to collect, release and analyse geographically classified statistics.

Bagasse

Bagasse is the fibrous stalk of sugar cane which remains as residue from the sugar cane milling process. It is typically used as a fuel to produce electricity for the milling and refining

of sugar cane.

Bio diesel

Bio diesel is an oil produced from renewable organic sources containing fatty acids using a process of condensation called transesterification.

Bio ethanol

Bio ethanol is ethanol produced from renewable organic sources, typically from agricultural feedstocks such as sugar cane.

Biofuels

Biofuels are fuels produced from renewable organic sources. Biofuels include bioethanol and biodiesel which are commonly used as transportation fuels, and landfill gas which is often used in the generation of electricity.

Black liquor

A liquid residue formed during the pulping of wood to make paper, having a high concentration of lignin and capable of being used as a biomass fuel.

Conversion loss

The generation of energy typically involves its conversion from one form (e.g. coal) into a preferred form (e.g. electricity). In such a conversion part of the original energy is lost, for example, through dissipation in the form of heat, and this is termed a conversion loss.

Direct employment - renewable energy

Direct employment in renewable energy activities is employment directly related to the production of renewable energy, and/or by the design, construction and/or maintenance of renewable energy infrastructure. See also "Indirect employment - renewable energy".

Electricity

Electricity is the flow of electrical power or charge. Electricity is commonly derived from burning organic matter, especially coal and natural gas. Other sources include hydro, wind and biomass.

Employment factor

An employment factor describes the number of FTE employees required to manufacture, assemble and install one unit of renewable energy generation capacity. See also "Employment factor approach".

Employment factor approach

The employment factor approach is a method used to estimate FTE employment in renewable energy activities. It combines an employment factor with a measure of renewable energy generation capacity. See also “Employment factor”.

Environmental accounts

Environmental accounts are accounts produced using the principles of the System of Environmental-Economic Accounting (SEEA). These accounts are produced in a systematic manner, using underlying principles that allow their integration with information produced in accordance with the System of National Accounts. See also “System of Environmental-Economic Accounting”.

Full time equivalent (FTE)

Full time equivalent (FTE) employment is a unit of employee workload whereby employee numbers are expressed in terms of the hours of a typical full-time employee. Thus, the FTE of a full-time staff member is equal to 1.0. The calculation of FTE for part-time staff is based on the proportion of time worked compared to that worked by full-time staff performing similar duties. The use of FTE enables comparisons of employee workloads across various contexts.

Geothermal power

Geothermal power is generated by using the thermal energy naturally generated and stored in the Earth.

Hydropower

Hydropower (hydro) is a process in which flowing water is harnessed to generate power, usually as electricity.

Indirect employment - renewable energy

Indirect employment in renewable energy activities comprises all employment related to the production of intermediate inputs related to installing, operating and maintaining renewable energy infrastructure. See also “Direct employment - renewable energy”.

Kilowatt (kW)

A Kilowatt (kW) is a measure of electric power, equal to one thousand watts.

Kraft milling process

The kraft process (also known as kraft pumping or sulfate process) is the process of

conversion of wood into wood pulp, which consist of almost pure cellulose fibres, the main component of paper.

Landfill gas

Landfill gas results from the breakdown of putrescible materials in waste deposited at landfill sites. This gas may be used to drive turbines to generate electricity.

Megawatt (MW)

A Megawatt is a measure of electric power, equal to one million watts.

National accounts

The national accounts are a systematic summary of national economic activity produced in accordance with the recommendations of the System of National Accounts (SNA). At a detailed level they show a statistical picture of the performance and structure of the economy. For further information please refer to the [Australian System of National Accounts: Concepts, sources and Methods \(https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/5216.0Main+Features12015\)](https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/5216.0Main+Features12015) (cat. no. 5216.0).

Non-profit institutions

Non-profit institutions (NPIs) are organisations that are not-for-profit and non-profit-distributing; they are institutionally separate from government and are self-governing.

Petajoule

A petajoule is a measure of energy, equal to 1,000,000,000,000,000 (10 to the power of 15) joules.

Production boundary

The SNA production boundary is a definition of activities deemed to be 'productive' and therefore to be included in SNA measures of output and production. The production boundary thus determines the size and nature of national accounting aggregates such as Gross Domestic Product (GDP).

Renewable energy activities

Renewable energy activities are those activities principally motivated by the production of renewable energy, and/or by the design, construction and/or operation and maintenance of renewable energy infrastructure.

Roof-top solar photovoltaic (PV)

Roof-top solar photovoltaic (PV) is a renewable energy generation system that uses PV

modules ('solar panels') sited on a rooftop to convert solar energy into electricity. A solar inverter converts this electricity from direct current (DC) to alternating current (AC) to match the type of electricity coming from the network.

Satellite accounts

Satellite accounts are accounts that provide a framework linked to the core national accounts and which enable attention to be focussed on a particular field or aspect of socio economic life in the context of the national accounts.

Solar energy

Solar energy refers to energy used for electricity generation (by photovoltaic conversion or solar thermal generation) and to energy used to heat water in solar hot water systems.

Solar hot water system (HWS)

A solar HWS uses solar collectors to absorb energy from the sun and heat water.

System of Environmental-Economic Accounting (SEEA)

The central framework of the System of Environmental and Economic Accounting (SEEA) is an international statistical standard for environmental-economic accounts ('environmental accounts'). It is a multipurpose conceptual framework for understanding interactions between the economy and the environment, and for describing stocks and changes in stocks of environmental assets. It is consistent with the SNA.

System of National Accounts (SNA)

The System of National Accounts (SNA) is an international statistical standard for economic accounts. It is a framework that provides a comprehensive, consistent and flexible set of macroeconomic accounts for a range of applications. It is consistent with the SEEA.

Wind power

Wind power refers to the conversion of wind energy into electricity using wind turbines.

Quality declaration - summary

Institutional environment

For information on the institutional environment of the Australian Bureau of Statistics (ABS), including the legislative obligations of the ABS, financing and governance arrangements, and mechanisms for scrutiny of ABS operations, please see [ABS Institutional Environment](#)

<https://www.abs.gov.au/websitedbs/d3310114.nsf/4a256353001af3ed4b2562bb00121564/10ca14cb967e5b83ca2573ae00197b65!OpenDocument>).

In producing the experimental estimates contained in this publication the ABS has used three broad approaches. These approaches are as follows:

1. Accessing publicly available information such as company annual reports, information provided on company websites, industry association reports and data drawn from the Renewable Energy Certificate (REC) Registry maintained by the Clean Energy Regulator.
2. Making use of the employment factor approach. This approach is a modelling technique that utilises information on installed capacities of renewable energy infrastructure, numbers of installations and employment factors. Employment factors indicate the number of annual direct Full Time Equivalent (FTE) jobs created per physical unit of choice, for example, numbers of annual FTE employees created per megawatt (MW) of installed capacity of wind power. It is an estimation technique that has been widely used internationally to estimate employment numbers associated with renewable energy activities.
3. Using employment numbers provided directly by the institutional unit.

Relevance

Employment in Renewable Energy Activities, Australia (cat. no. 4631.0) presents estimates of annual direct full time equivalent (FTE) employment in renewable energy activities, by state and territory and by type of renewable energy. These estimates are the third set of official Australian estimates of FTE employment in renewable energy activities and will allow analysts to better understand employment patterns in Australia. They update and replace the previous sets of estimates of employment in renewable energy activities, released in April 2015 and March 2016.

Timeliness

Estimates of annual direct full time equivalent (FTE) employment in renewable energy activities contained within Employment in Renewable Energy Activities, Australia are released within 9 months of the end of the reference period.

Accuracy

Data published in Employment in Renewable Energy Activities, Australia are considered

analytically useful but are also considered experimental and data quality is expected to improve in subsequent editions of this publication.

Coherence

This publication contains experimental ABS estimates of employment in renewable energy activity. The definitions of employees and employment used in this publication follow the [System of National Accounts \(http://unstats.un.org/unsd/nationalaccount/sna2008.asp\)](http://unstats.un.org/unsd/nationalaccount/sna2008.asp) and are consistent with those used throughout ABS employment statistics.

Interpretability

The explanatory notes of this publication contain four sections, which cover:

- Scope of renewable energy activities
 - Categories of renewable energy activities
 - Direct and indirect employment in renewable energy activities
 - Estimation methodology.
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Accessibility

The data contained in this publication comprise the full detail of publishable data for Employment in Renewable Energy Activities, Australia and as such it is not possible to provide any further information beyond that presented in the publication. Tables contained in this publication are available in spreadsheet format in the Data downloads section. For more detail on the publication please contact the National Information and Referral Service on 1300 135 070.

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Abbreviations

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ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
ANZSIC	Australian and New Zealand Standard Industrial Classification
ARENA	Australian Renewable Energy Agency
ASGS	Australian Statistical Geography Standard
CEFC	Clean Energy Finance Corporation
DC	Direct current
DoEE	Department of Environment and Energy
ESC	Essential Services Commission
FIT	Feed-in tariff
FTE	Full time equivalent

GDP	Gross Domestic Product
HWS	Hot water system
ICT	Information and Communication Technologies
IPART	Independent Pricing and Regulatory Tribunal
IRENA	International Renewable Energy Agency
kW	kilowatt
kWh	kilowatt hour
LRET	Large-scale Renewable Energy Target
MW	megawatt
NPIs	Non-profit institutions
NSW	New South Wales
NT	Northern Territory
PJ	petajoule
PV	photovoltaic
Qld	Queensland
REC	Renewable Energy Certificate
RET	Renewable Energy Target
SA	South Australia
SEEA	System of Environmental-Economic Accounting
SEEA - CF	System of Environmental-Economic Accounting - Central Framework
SNA	System of National Accounts
SRES	Small-scale Renewable Energy Scheme
Tas.	Tasmania
Vic.	Victoria
WA	Western Australia